A draft Curriculum for 'Geoscience and Sustainable Development' developed by Prof. Saumitra Mukherjee, School of Environmental Sciences, Jawaharlal Nehru University under the aegis of the Committee XII of Central Geological Programming Board Committee – XII on "Geoscience for Sustainable Development" of the Central Geological Programming Board [CGPB] of the Geological Survey of India [GSI] under the Chairmanship of Sh. G. Srinivas, Joint Secretary [Minerals and Regulation], Ministry of Mines [MoM] is hereby kept for perusal and comments from academics/ geoscientist/ mineral industry and other interested persons for finalization of the curriculum.

The comments may be sent to the Director(Technical), Ministry of Mines (e-mail : dirtech.mom@nic.in) latest by 20th February 2012.

Capacity building in Geosciences and Sustainable development

Professor Saumitra Mukherjee, PhD, PGDEE, Commonwealth Fellow(UK), IUGG(USA),Professor of Geology, Remote sensing and Space Sciences, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi-110067, Email: saumitramukherjee3@gmail.com

The UNCED Environmental Conference in Rio deJaneiro 1992 has changed the world. Geoscientists entered the environmental ?eld relatively late, however, geological surveys and geoscienti?c research institutes adapted to this situation and have placed geo-environmental issues high on their agendas. These include water, soil, poverty alleviation, urbanisation, waste disposal, energy, minerals, disaster reduction and education. Although geoscientists cannot prevent nor cure all of the world's major problems, their ability to cope with long time and wide space scales together with their advanced technologies can and must contribute to solving many of society's problems. This, however, requires a new and untraditional type of geoscientist.

GEOSCIENCE AND SUSTAINABLE DEVELOPMENT Study involves understanding of two major set of conditions:

(i) physical conditions and

(ii) social and cultural conditions.

Physical conditions constitute mostly the abiotic attributes of the environment such as the earth material, minerals, soils, water, landforms, air that together affect growth and development of man.

The social and cultural conditions include environmental parameters such as the ethics, economics, aesthetics, etc. which affect the behavior of individuals or a community.

Environmental geological appraisals of a terrain recognize the potential hazards and resource utilization pattern. These Investigations are either site specific or problem specific respectively. Environmental geoscientific studies by GSI involve preparation of various thematic and derivative maps, syntheses of collateral and primary data and finally integrated comprehensive and synoptic output is generated in the form of geoenvironmental maps showing environmental hazards and the potential resource utilization pattern. Based on the land-capability assessment, a suggested landuse map is prepared for overall regional development and optimum resource utilization for sustainable development in the area. Further specific details on the various geofactor considerations and analyses of their environmental impacts are provided and discussed in the following sections.

Public concern over global environmental change and the likelihood of the Earth remaining a healthy environment for future generations is commonly expressed in the phrase 'sustainable development'. Valuable information on econometric aspects of 'development', specifically in developing countries is important. Because earth scientists are used to dealing both with development and with the environment and are especially capable ofviewing global environmental change in correct spatial and timeframeworks, they are particularly well equipped to contribute to ‘sustainable development’. Requirements and issues for arriving at sustainable development often contain Earth-related aspects. Therefore, it is advisable that earth scientists are involved in realising such requirements, preferably alongside experts in other scientific and non-scientific disciplines. These requirements and issues include: water, soil, urbanisation, waste disposal, energy, minerals, and disaster reduction. Geoscientific aspects of these key requirements for sustainable development are mainly:

Water

In numerous recently published state-of-the-environment reports, water turns out to be the factor most limiting sustainable development. In the next decade the availability of fresh water will dictate all agendas of development, not only in developing countries, and might cause political instability in larger dry regions on Earth. Peace agreements in the Near East, for example, invariably include major chapters on regional water management. The availability of fresh potable water is seriously restricted by: 1) depletion of aquifers and 2) pollution of both surface and groundwater resources. The problem of aquifer depletion is partly caused by inadequate aquifer management (over-exploitation, poor recharge, etc.) but mainly by the fact that ever-smaller quantities of fresh groundwater will have to supply more and more people on earth. As professional explorers, geoscientists can assist in mitigating aquifer depletion by identifying new fresh, often deeply seated and more remotely situated groundwater resources. Geoscientists can also be involved in upgrading groundwater management by optimizing the spatial distribution and extraction depths of groundwater wells. They are well equipped to detect and delineate pollution flumes in aquifers and their potential propagation through the system. At first sight, the role of geoscientists in preventing pollution of groundwater and surface water resources may be less obvious. However, their three-dimensional knowledge of the earth's structure, its composition and that of the sediment/rock properties, together with their knowledge on the sediment-groundwater interaction, allows them to feed groundwater-flow models that simulate flow paths with sound data and to calculate the retention capacities of strata to certain polluting elements. Geo-forecasting has become a very promising tool for water management and can lead to measures that will prevent valuable aquifers from being contaminated.

Soils

Agricultural soils are seriously under threat. The formation of agricultural soils is a slow process taking place at the rate of a few
millimetres per year. Man’s activities such as deforestation, poor or totally absent land-use management techniques (e.g. slash and burn),and inadequate or excessive use of fertilisers and agrotoxics, have resulted in extensive soil losses or soil degradation. In the People’s Republic of China 5 billion tonnes of fertile soil is lost annually, 2 billion tonnes of which is transported by rivers and deposited in oceans or in lakes. This equals 1/12th of the world’s total. Other types of land loss are desertification and salinisation. The equivalent of 5 to 6 million hectares of soil is lost every year, making soil erosion one of the worst factors limiting sustainable development. Overall, sustainable agriculture can only be achieved when soil erosion and degradation do not exceed replacement. At human time scales and with the current practices soil has become a non-renewable resource and a fundamental constraint to sustainable development. Geoscientists may apply their knowledge of the fluvial and marine/coastal processes to contribute to the understanding of the local and regional problems and thus predict and pinpoint jeopardized areas

of fertile land. Application of erosion models could help to design planning and management systems to prevent fluvial and coastal (soil) erosion.

Urbanization

50% of the Earth population lives in cities that cover only a few percent of the total land surface of the globe. 'Sustainable urban development' is therefore a matter of high priority on the international environmental agendas. The concentration of high-rise buildings, underground structures, steep slope cuts, excessive groundwater extraction poses large differential stresses on relatively small areas of land, causing imbalance and creating major geo-hazards. Urban geologists collect and process subsurface data and communicate their three dimensional view on the city's subsurface to urban managers and planners. When economic and legal data are added, reliable, but indicative cost/benefit analyses can be provided. Subsequently, site selection can be based on unbiased data through decision-support systems. Such systems may provide transparent tools understandable for urban managers and for the ever more concerned urban public. Urban geoscientists have joined to form the International Working Group on Urban Geology.

Waste disposal

Poor waste management often seriously obstructs sustainable development. The over 40-metre-high waste dump ('smoky mountain')of Manila in the Philippines presents a major threat to the environment in and around this megacity. Domestic waste is mostly stored on or near the surface near or in the immediate vicinity of urban centres. Too often such waste dumps are poorly designed and lack an adequate lining underneath the dump site and/or are situated on permeable beds allowing leachate to enter the aquifers. Studies on storing waste materials are generally limited to the engineering aspects of preselected sites. The availability of natural geological barriers preventing transport of contaminants into aquifers is taken into account only occasionally.Sustainable waste disposal is more and more based on the 'multi-barrier' principle, taking into consideration impermeable or poorly permeable beds such as thick clay bodies, rock salt or shales as the last (natural) barrier to leachates before entering into the biosphere. This particularly applies to highly toxic radiation waste such as high-level radioactive waste. The generally very strict site-assessment procedures used for this waste category, however, often do not apply for other types of waste, even if this concerns highly dangerous and everlasting chemical waste materials. Sites for radioactive waste disposal are generally selected for logistic, administrative and political reasons. Another factor obstructing radioactive-waste storage is the policy that such waste has to be stored in a country's or province's own territory. There is, however, no guarantee that a suitable site can be found there and a less appropriate site may then be selected. The enormous potential environmental impact of such hazardous waste in the long term provides a good enough argument in itself to question this policy and to search for premium sites even if these are not in the national territory. If one considers the dramatically changed positions of national borders in a continent such as Europe over the past two centuries only, the current solely national studies on radioactive waste disposal which should be safe for at least 10,000 years (e.g.USA), 100,000 years (e.g. Germany, the Netherlands) or one million years (e.g. Sweden) lack a well-considered and realistic time/space concept. The study by the GSI for the best possible site for permanent storageof radioactive waste is therefore welcomed. Waste management will become increasingly important in the coming years. Although it is expected that eventually less waste will be produced per person in a more developed world, an increase in waste production in the less developed world cannot be avoided during the next few decades. It will probably not take long before multinational companies will employ both exploration and environmental geoscientists in their efforts to find places where such waste can be stored in an environmentally sustainable and cost-effective way.

Energy

Non-renewable energy resources such as oil and natural gas are being gradually but irrevocably depleted. In view of the fact that the need for energy keeps pace with population growth, it is evident that the search for and wise use of energy resources deserves a prominent position in development agendas. This concern, however, is not reflected in the energy price in most countries which 'subsidise' energy delivery through a system of low taxes. If environmental resource accounting were applied fully to oil and gas, prices would be increased considerably in e.g.the U.S.A. This, in turn, might discourage excessive and wasteful use of these valuable resources. Very large resources of black and brown coal still exist in the earth. These resources are predominantly mined and utilised in developing countries, causing massive CO_2 emission. In addition, large quantities of CO_2 are emitted into the atmosphere by spontaneous coal combustion. Such "coal fires"occur frequently in China, India, and Indonesia and consume 100-200 million tonnes of black coal in China every year. Geoscientists are currently involved in combating these major environmental problems. They are also involved in studies on the storage of large volumes of this greenhouse gas in depleted natural gas reservoirs. Techniques have become available of producing natural methane gas from buried coal beds in a more environmentally friendly way or by controlled underground coal combustion. A great challenge for the earth science community in the coming decades will be the exploitation of solid methane hydrates occurring at great depths particularly in the ocean floors and under permafrost areas and holding enormous potential energy resources. In large regions of the world people rely almost entirely on wood for fuel causing deforestation which clearly has a negativeimpact on the environment through reduction of O_2 production, reduction of biodiversity, increased soil loss and erosion, excessive sedimentation and landslides. Geoscientists can predict such environmental problems and assist planners to develop less harmful solutions.

Minerals

Governments are increasingly concerned about the environmental impact of the mining industry and impose severe environmental constraints on mining activities. As a result, for instance, Canadian copper mining companies moved to Chile. Environmentally sustainable mining is expensive whereas mineral prices are still low. Only mining of high-grade ores can be economic and then only on very large scales. To find such sites requires great expertise in exploration and thus geological skills. The same applies to relatively cheap aggregates and construction materials. In densely populated countries such as the Netherlands, combined extraction pits for both clay and coarse sand are becoming increasingly common, consequently the landscape is spoilt less.To assess the geochemical impact of mining and the environmental impact of its tailings, geoscientists are needed as well. They may contribute to the development of adequate chemical, physical or biological ex-situ and in-situ remediation methods for polluted or unstable tailings. In addition, geoscientists can play a key role whenit comes to environmental monitoring because they are familiar with the geochemistry of mining. To this end it is essential to measure the original background values of the soil geochemistry. Since these are closely connected with the natural geological conditions of rocks and soils, establishing a reliable picture of the zero levels should essentially be the job of geoscientists.

Disaster reduction

In the framework of the International studies of Natural Disaster Reduction of the United Nations annual reports have been compiled on the impact of the world's natural disasters. Such reports show that in the period 1990–2011, more than 300,000 people were killed or reported missing as a result of natural disasters, such as earthquakes, floods and landslides. The total economic losses caused by these disasters in that period exceeded 500 billion US$, which is about 0.2% of the world's Gross Product. The results of assessing and monitoring the impacts of natural and man-induced disasters/hazards clearly demonstrate the need for prediction and prevention tools. As geological processes form the basis for calculating the effects of such hazards, prediction models should inevitably be based on geoscientific expertise. While such predictions were mainly qualitative in the past, an increasing number of Earth processes have been approached in a mathematical-physical way during the past decade, leading to the development of steadily improving numerical models. Such models can now simulate the future effects of certain geological processes under varying conditions. Other hazards are related to global change as a result of the increased emission of greenhouse gases. As global change problems encompass the entire Earth including its geosphere, hydrosphere, biosphere and atmosphere, an integrated approach which considers the Earth as a single system is now preferred. Geoscientists currently contribute to studies concerning the anticipated harmful effects of global change. Firstly, the climatic effects of varying amounts of such gases under natural conditions in the atmosphere during the geological past are now studied by many Quaternary geologists. Such studies have for instance resulted in considerably more precise dating of past climatic events and to a much better understanding of the natural increase and decrease of greenhouse gases in relation to glacial and warm periods both on time scales of 200,000 and 2,000 years. Another aspect of global change concerns the impact of an accelerated sea-level rise on the present-day coastal zones. In this respect it has become clear that only an integrated approach taking into account the interests of all stakeholders in such regions, can lead to reliable predictions concerning the areas which are threatened by marine flooding. Global change will not only affect sea levels but also climatic conditions in monsoon areas.

Promising results have been achieved by geoscientists in studies on the Carbon Cycle which quantify the volume of Carbon lost in sinks and that produced in the sources of the Earth System as an approach to estimating the contribution of natural CO2 to the atmosphere. It is becoming increasingly clear that the great efforts in developing global climate models will have been in vain if these are not fed with and evaluated against reliable geological data. Often poor modelling results have forced modellers to contact geoscientists to provide such data.

Socio-economic aspects of development

Apart from the listed environmental requirements for sustainable development, several major and general socio-economic issues also need geoscientific input to achieve sustainable development.

Poverty alleviation

UNDP considers poverty alleviation the most important factor in achieving sustainable development. Poverty is the driving force of land degradation because it induces unsustainable land-use practices. Furthermore, 'real' sustainable development can only be approached when ethical principles of human solidarity are applied. Poverty alleviation is often seen as a social issue only. However, several aspects of poverty mitigation, such as health and safety, should be regarded by more physically oriented disciplines, among which are the geosciences. Several health problems are directly or indirectly related to the geological conditions of the area where people live, particularly in developing countries. Such issues are now addressed by geoscientists and the medical sector together.

Education

Population growth and poverty are strongly associated with illiteracy. Thus, one of the basic tools to combat poverty and population growth is elimination of illiteracy. Education is therefore one of the key elements for arriving at sustainable development. New development models requiring all available knowledge and co-operation between all target groups, have been designed in the past decade. An example of such a model is 'Integrated Coastal Zone Management' in which all factors in the coastal zone are involved in the decision-making process. This model is fed with all kinds of information, including earth-scientific information and has a strong emphasis on environmental elements. For this shift in approach re education is needed, not only for the young generation but for people at management levels as well. A similar approach is needed for studying the impacts of Global Change on the hydrosphere, geosphere, biosphere and atmosphere. This again puts strong pressure on the educational system which should basically be modified from discipline-oriented to integrated science studies. To solve environmental problems, the geosciences should be fully integrated with other disciplines. If we would modify the educational systems and adopt new curricula, future students will become familiar with problem solving in an integrated way from the start.

Value of geosciences for sustainable development

The listed requirements for environmentally sustainable development show that geoscientists will have a significant role to play, both in the next decade and beyond:

1. Geoscientists can contribute to the alleviation of the anticipated shortage of fresh water by finding new underground resources, by optimising groundwater exploitation, by creating new aquifers through land reclamation and natural recharge, and by forecasting flow paths of pollutants in aquifers.

2. Geoscientists can contribute to the mitigation of the foreseen reduction in fertile land area by developing measures to prevent soil loss both as a result of erosion and of soil contamination.

3. Geoscientists can contribute to the prevention of the negative effects of uncontrolled urbanisation by finding new resources (fresh water, fertile soils, construction and energy materials, minerals, etc.) for the citizens, by predicting natural and man-induced hazards and warning the municipal authorities of unstable and/or risky areas, by assisting in the selection of optimal sites for urban expansion and urban land use and by developing urban geo-information systems and decision-support systems to assist urban planners, developers and to inform the citizens.

4. Geoscientists can contribute to selecting suitable sites for waste dumps, either underground, in the ground or on the surface, by identifying appropriate, natural, geological barriers which will last much longer than the best geotextiles, by predicting potential contamination patterns, by applying the geologically determined natural attenuation capacity of deposits in the subsurface, and in the development of geo-remediation strategies.

5. Geoscientists can contribute to solving the world's energy problems by finding new resources, by developing methodologies for unconventional energy production in e.g. underground coal beds, by reducing wastage of energy resources during production, storage and transport, or by combating 'coal fires'. In addition, they can contribute to mitigating the negative effects of energy production by predicting the environmental impact of the unsustainable use of energy resources, by assessing potential sites where radioactive waste or CO_2 can be safely stored underground.

6. Geoscientists can continue to substantially contribute to the economy by finding new mineral resources. In addition, they can
contribute to the mitigating of the negative effects of mining and mineral processing by predicting the environmental impact of such activities, by applying such information for environmentally sustainable siting of plants and (super)quarries, and by developing and applying proper (biogeo-)remediation methodologies.

7. Geoscientists can further contribute to disaster reduction by redicting geo- and man-induced hazards and their impact on society, by constructing hazard zonation maps, by alerting authorities to the effects of global change, such as geologically realistic estimates of sea-level rise and droughts. They can also contribute by developing mitigation methods and early warning systems.

8. Geoscientists can even contribute to poverty alleviation and to arrive at a better public health situation by exploring for unpolluted, fresh water resources for the poor, by promoting integrated coastal zone and land management taking into account the demands of the poor, by mitigating land deterioration resulting in higher crop yields, and to a safer housing situation by reducing potential geohazards.

9. Finally, geoscientists can contribute to improved education by supporting environmental education programmes both at grassroots level and at the level of planners and politicians, e.g. through educating local decision-makers in the geological background of natural and man-induced hazards. Increasing awareness of the essential role geosciences can play in environmental planning and management, will also contribute to the general education level of people.

Geoscientists can and must contribute to solving the basic problems of mankind in the next decade, even more than today. The targets and job markets for geoscientists will shift from the traditional exploration sector towards the service sector. A new type of geoscientist is emerging: client-oriented geo-clerks with broad, multidisciplinary backgrounds including non-geoscientific topics and information technology, who will not solely focus on a geological approach for problem solving, but who will try to develop a total solution from a holistic approach.

Following Syllabus is suggested for Sustainable Geosciences.

Earth Processes

Ecology

Environmental Pollution

Natural hazards and disaster management

Environmental Impact Assessment
Energy and Environment
Remote sensing and Geo- informatics
Environmental Biochemistry and Toxicology
Marine Environment
Soil Science
Current Environmental Issues
Geosustainance Modeling
Climatology
Meteorology
Geochemistry
Water Resources
Oceanography
Natural resource Management
Glaciology
Biogeochemistry
Environmental Geology
Water Pollution Chemistry
Soil Pollution Chemistry
Solid and Hazardous Waste Management
Pollution Biology
Biodiversity and Conservation
Forest Ecology
Ecosystem Dynamics
Ecology and Sustainable Development
Bioremediations
Eco-Toxicology
Environmental and Occupational Health
Mining and Environmental Laws
Remedial Mathematics
Remedial Biology
Statistics
Environmental chemistry

Earth Processes

Evolution of various branches of Geology. Origin of the earth. Primary differentiation and formation of core, mantle, crust, atmosphere and hydrosphere. Magma generation and formation of igneous and metamorphic rocks. Concept of Minerals and Rocks. Weathering, erosion, transportation and deposition of earth's materials by running water, wind and glaciers. Formation of land forms and sedimentary rocks. Plate tectonics- sea floor spreading, mountain building, evolution of continents and structural deformation. Thermal, magnetic and gravitational fields of the earth. Concepts of engineering and urban geology.

Ecology

History and scope of ecology, autecoloty, synecology, population, community, biome, tolerance range and limiting factors. Distinguishing characters of forests grasslands, arid lands and wetlands; community organization- concept of habitat, functional role and niche, key stone species, dominant species, ecotone, edge effect. Analytical characters, synthetic characters like forms, species diversity and measurement of diversity. Population dynamics, models for single and interacting population, stable points, stable cycles, chaos competition, prey predation, etc. Ecological succession, primary and secondary processes in successions, models of successions, climax community and types of climax. Vegetation of India. Fundamentals of Microbial ecology. Microbial metabolism and microbial interaction. Biochemistry of biological nitrogen fixation and other microbial Pathways in terms of enzymology.

Environmental Pollution

Linkage between energy, environment and development. Human population issues. Definition of pollution. Different types of pollution- Air, Water and soil and their local, regional and global aspects. Air: Sources of air pollutants, their behavior in the atmosphere. Effects of air pollutants on humans, animals, plants and properties. Control approaches. Water: Sources, effects, water pollution treatment. Soil: Sources and nature of soil pollution and its harmful effects. Solid waste: generation, collection, environmental effects and safe disposal practices. Environmental problems associated with noise pollution, oil pollution and radioactive pollution.

Natural hazards and disaster management

Introduction to Hazards- Hazard classification-types of hazards ;Natural Hazards: causes, (continental drift, plate tectonics, sea floor spreading, isostacy, etc.,) distribution pattern, consequences and mitigation: Earthquake, Tsunami, Volcanoes, Cyclone, Flood, Drought, Landslide, cold and heat hazards, forest fire, etc.,- causes, types, distribution adverse effects, etc.,- Disaster introduction- disaster Management Capability-Vulnerability- risk- preparedness and mitigation- Disaster management cycle- community planning education and Engineered structure /structural strengthening techniques- Hazard zonation and mapping- Risk Reduction Measures.

Environmental Impact Assessment

Linkage between development and environment; global commons: carrying capacity: origin and development of EIA: relationship of EIA to sustainable development: EIA in project planning and implementation: EIA process: evaluation of proposed actions, scoping and base line study, identification and prediction of impacts, mitigation measures. Comparison of alternatives, review and decision making, public participation and compensatory actions: green belts: National Environmental Policies and guidelines in India. Conditions and approach for EIS review. Case studies: river valley projects: thermal power plants: mining projects: oil refineries and petrochemicals.

Energy and Environment

Energy resources and their exploitation, Sun as source of energy- nature of its radiation, Conventional energy sources: coal, oil, biomass and nature gas, non-conventional energy sources: hydroelectric power, tidal, wind, geothermal energy, solar collectors, photovoltaics, solar ponds, nuclear-fission and fusion, magneto-hydrodynamic power (MHD), Energy use pattern in different parts of the world and its impact on the environment. CO2 emission in atmosphere.Mechanism of radiation action on living systems- Stochastic and Non-stochastic effects; delayed effects, radioactivity from nuclear reactors, fuel processing and radioactive waste, hazards related to power plants, terrestrial and non terrestrial radiation, dose from environment and nuclear radiations, ultraviolet radiations, pathways analysis and dose assessment, radiologic age dating, radioactivity risk assessment, criterion for safe exposure.

Remote sensing and Geo- informatics

Introduction to Remote sensing & GIS. Principles of remote sensing & GIS. Spectra of Environmental Components. Terrestrial and Extra terrestrial satellites in Remote sensing and GIS. Remote sensing & GIS applications on Ocean, Atmosphere, Land, Geology, Water Resources (Ground water and Surface water). Cryosphere, Disaster, Defence studies. Use of softwares in Remote sensing and GIS to solve Environmental problems including Groundwater Exploration, Rainwater Harvesting, Biomass analysis and its relationship with Georesource evaluation. Use of Remote sensing and GIS in development of Early warning system to monitor Agriculture. Identification of Genetically modified crops in correlation with water quality and soil moisture by using Remote sensing & GIS. Applications of Remote sensing and GIS in early warning of Tsunami, Earthquake, Snowfall, Global warming, Forest fire, Landslide, Landsubsidance. Use of LANDSAT, SPOT, IRS ERS, RADARSAT and Extra terrestrial satellite data by using ERDAS, ARCGIS, ERMAPPER, IDRISI ENVI and S+ software for solving the Environmental problems. Sun-earth cosmic connection to understand environment of the Earth.

Environmental Biochemistry and Toxicology

Environmental physiology with considerations of intermediary metabolism- approaches for studying energy metabolism and body temperature changes; Thermo regulation and adaptation. Oxygen uptake from the environment, respiration and metabolism. Electron transport system and oxidative phosphorylation. Photosynthesis: C1, C3, C4 pathways and their regulation. Photorespiration. Biochemistry of altered membrane permeability, free radical formation, lipid peroxidation, lysosomal degradation, superoxide dismutase. Environmental pollutants and their effects on living system. Biochemical approaches to the detoxification of xenobiotics through cellular metabolism.

Marine Environment

Introduction-Classification- open ocean- shallow marine and deep sea environment- marine resources- marine ecology- marine organisms-productivity- coastal environment-coastal water movement- beaches- coastal dunes- barrier islands- cliffed coast- deltas-coast line- estuaries- mangroves- lagoons- salt marshes- coral reefs- classification of marine sediments- clay minerals- biogenic silica- evaporites- nutrient in oceans- carbon and global climate change- marine pollution- law of the sea.

Soil Science

Soil forming rocks and minerals- Classification- Weathering of rocks and minerals- Processes of weathering and factors affecting them. Soil formation- Factors of soil formation- Soil forming processes- Profile development- Definition of soil- Soil composition.

Soil physical properties- Soil separates and particle size distribution- Soil texture and structure- Bulk density, particle density, pore space, soil air, soil temperature, soil water, soil consistence - Significance of physical properties to plant growth.Soil chemical properties- Soil colloids- Inorganic colloids- Clay minerals- amorphous- Ion exchange reactions- Organic colloids- Soil organic matter- Decomposition- Humus formation- Significance on soil fertility, Soil reaction- Biological properties of soil- nutrient availability.

Current Environmental Issues

Contemporary and emerging environmental issues of local, regional and global significance. Broadly the topics will be pertaining to: i) Linkage between population, development and environment ii) climate change ii) stratospheric Ozone depletion iii) water resources iv) environmental toxicants and human health v) biodiversity conservation and vi) Mining environmental episodic events, etc.

Geosustainance Modeling

Role of Modeling in Sustainable Geoscience. Model Classification- Deterministic Models, Stochastic Models, Dynamic Models, Steady State Models. General Steps Involved in Modeling, Mass Balancing, Energy Balancing, Microbial Growth Kinetics- Exponential Growth Model, Logistic Growth Model, Monod Equation, Two Species Population Growth Model of Competition. Lotka-Volterra Prey-Predator Model, Oxygen Sag Model, Gaussian Plume Model.

Climatology

Elements of climate, climate controls, Earth's radiation balance, latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance, spatial and temporal patterns of climate parameters, Air masses and fronts, SW and NE monsoon, jet stream, tropical and extratropical cyclone, ENSO, QBO. Classification of climate- Koppen's and Thornthwaite' scheme. Climate change

Meteorology

Elements of climate, climate controls, Earth's radiation balance, latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance, spatial and temporal patterns of climate parameters, Air masses and fronts, SW and NE monsoon, jet stream, tropical and extratropical cyclone, ENSO, QBO. Classification of climate- Koppen's and Thornthwaite' scheme. Climate change

Meteorology fundamentals- Pressure, temperature, wind humidity, radiation, atmospheric stability diagrams, turbulence, diffusion. Thermal structure of the atmosphere and its composition, radiation from sun, solar constant, effects of cloud, surface and planetary albedo, emission and absorption of terrestrial radiation, radiation windows, greenhouse effect, net radiation budget, thermodynamics of dry and moist air, specific gas constant, adiabatic and isoentropic processes, entropy and enthalpy, moisture variables, virtual temperature, adiabatic processes of moist air, thermodynamic diagrams, dry and moist air parcel, T-phigram and mixing height

Geochemistry

Atomic properties of elements, the periodic, table and geochemical classification of elements; abundance of elements in the bulk earth, crust, hydrosphere, atmosphere and biosphere; introduction to mineral structures and compositions; thermodynamic classification of elements into essential, structural, major and trace elements and their partitioning during mineral formation; chemical reactions involving proton and electron transfers, mineral stability diagrams and controls on the chemistry of natural waters; geochemical cycling-concepts with an example; radioactivity, decay of parent and growth of daughter nuclides and methods of radiometric dating; stable isotopes, their fractionation and application to geothermometry and paleoclimates. Interpretation of XRD and XRF data for Environmental components. Geochemical sample preparation. X-Ray Fluorescence. X-Ray Diffraction. Ion Chromatography, AAS and its interpretation.

Oceanography

Introduction- historical, current and future- Earths structure- Physiography of oceans- origin and evolution of ocean basins (Continental and oceanic basins)- Continental drift, sea floor spreading, plate tectonics- shelf and deep sea sedimentation- physical, chemical and biological aspects of sea water- Ocean current (circulation)- Waves properties and motion- tidal currents and characteristics- air-water interface/ exchange, gas solubility and circulation models.

Natural resource Management

Definition- land, water, soil, plants and animals: quality of life: renewable and non-renewable resources: Mineral occurrences, prospects: Mineral resources: Mineral reserves, ore minerals, coal, petroleum, oil and natural gas: water- hydropower, including tidal power; ocean surface waves used for wave power, wind- wind power, geothermal heat- geothermal power and radiant energy- solar power: sustainable development, Urban planning Environmental management, Understanding the resource ecology and life-supporting capacity of resources-Economic models: Green building concept- green technology concept.

Glaciology

Glacier systems- Structure and morphology of glaciers- Glacial erosion; Landscape evolution under glaciers, glacial landforms- Mass balance- Glacier dynamics, Englacial and subglacial process and fluctuations- Glacier hydrology- Snow and melt water chemistry of- Approaches to Glaciology- Glacier modeling- Glacier and climate change impact- Glaciers- Glacier and water resources- Recent advances in Glaciology- Spatial Data Acquisition Glacier Hazards- Glaciers as tool for palaeo climate studies.

Biogeochemistry

Introduction- Biogeochemical provinces- Atmosphere- Lithosphere: weathering process, soil biogeochemistry- Terrestrial systems: photosynthesis respiration- Wetlands: vegetation adaptations- Freshwater and Marine Biogeochemistry: Lakes, ponds, rivers, mangroves, salt marsh and estuaries- Oceans: productivity and limiting nutrient role, carbon chemistry- Global biogeochemical cycles: Nutrient cycles-Advances in biogeochemistry- Sediment biogeochemistry, stable Isotopes in Biogeochemistry and their application to various environmental problems. Nutrient dynamic in the atmosphere, hydrosphere, and Lithosphere. Nutrient budgeting and modeling

Environmental Geology

Interior of the earth- minerals and rocks- earth processes- plate tectonics- sea floor spreading, mountain building, rock deformation- evolution of continents and earth quakes, volcanoes, landslides, subsidence, rivers and floods and coastal process- interactions between humans and the geological processes, Environmental Hazards-Pollution of the Environment- Waste Disposal, Natural Resources, and Energy Sources and their exploitation. Past, present and future environmental issues and their affect on the earth and our society.

Water Resources

Hydrological cycle- Hydrometeorology and climate- hydrometric networks and catchment morphology- precipitation- evaporation and evapotranspiration- soil moisture-river flow- River, Lakes and Ground water- Occurrence of surface water and groundwater. Definition and concept of hydrology and hydrogeology. Distribution of water in the earth's crust. Hydrological cycle. Genetic types of groundwater and residence time of groundwater, Geological control of groundwater, Vertical distribution of groundwater, Types of aquifers, springs and their classification, Classification of rocks with reference to their water bearing properties. Mode of occurrence of groundwater in different geological terrains of India. Darcy's law and its validity, Determination of hydraulic conductivity, groundwater tracers. Environmental factors on Groundwater level fluctuations and Land subsidence due to changes in subsurface moisture. Effects of excessive use of groundwater resources. Sources of salinity, Chemical analysis of groundwater, Quality criteria for different uses, Groundwater quality in different provinces of India, pollution of groundwater resources. Ghyben-Herzberg relationship between fresh-saline water. Groundwater exploration. Construction and design of different types of wells. Well completion and development. Groundwater development and management: Groundwater development in urban areas and rainwater harvesting, artificial recharge methods. Management of groundwater and groundwater legislation.Movement of water on the surface and below the surface. Springs and Hydrothermal phenomena. Ungauged river basin flow- River bank infiltration and recharge-precipitation analysis- evaporation calculation-river flow analysis- Time variation of stream flow levels- rainfall- runoff relationships- Ecohydrology- urban hydrology- Integrated Water Resource Management (IWRM), Urbanization effect on Water resources. Earthquake, Land subsidence and Water resources. Physical, chemical and biological characteristics of Water resources and water quality data processing and interpretation. Sea water intrusion in aquifer system-structural geological approach. Influence of Sun-Earth cosmic connection on Water resources.

Water Pollution Chemistry

Physicochemical properties of water, Water use- classifications and water quality standard. Basic principles of contaminant behavior in the environment. Hydrologic cycle.

Types and sources of water pollution, Major Water Quality (physicochemical and bacteriological) Parameters and their Applications, Basics of water sampling.

Water quality objectives and the major chemical, physical and biological processes necessary for designing and managing modern drinking water and wastewater treatment plants, Principles of coagulation, flocculation, sedimentation, chemical precipitation, porous media filtration, disinfection, ion exchange, adsorption, membrane Processes, advanced oxidation processes, air-stripping and other advanced treatment processes, Major contaminant groups and natural pathways for their removal from water

Soil Pollution Chemistry

Physical Chemistry of Soil: Soil Solution Phase, The Soil/Solution Interface, Surface exchange reactions, Soil acidity, Electrochemistry and the Soil, chemistry of waterlogged soil.

Soil Pollution: Inorganic and Organic-Definition of pollution and contamination, sources of soil pollution, Effects of chemical residues on soil, (pesticides, fertilizers, heavy metals etc., Soil salinity and alkalinity, Soil pollution from nitrogen, phosphorus, sulfur, micronutrients or trace elements and radionuclide, land degradation, soil erosion.

Soil pollution and climate change: Greenhouse gases production, emission, mitigation, carbon sequestration, soil quality.

Solid and Hazardous Waste Management

Solid wastes: Definition, types, sources, characteristics, and impact on environmental health. Waste generation rates. Concepts of waste reduction, recycling and reuse. Collection, segregation and transport of solid wastes Handling and segregation of wastes at source. Collection and storage of municipal solid wastes. Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery. Composting, Vermicomposting, Incineration of solid wastes. Disposal in landfills: site selection, design, and operation of sanitary landfills; secure landfills and landfill bioreactors; leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation.

Hazardous wastes: Definition, sources and characteristics: Hazardous waste categorization, generation, collection, transport, treatment and disposal. Legislation on management and handling of municipal solid wastes and hazardous wastes.

Pollution Biology

Concepts: Pollutants vs. resources; cycling of materials, tolerance ranges, carrying capacity, bioaccumulation. Air Pollution: Responses of plants and animals, monitoring (e.g. lichens) and control of air pollution by plants. Water pollution: Responses of plants and animals to changes in physico-chemical characteristics; distribution of plants in relation to pollution (microphytes; Phytoplankton, periphyton and moorophytes); Biological monitoring and control of pollution in water. Soil pollution: Responses of plants to soil pollution; changes in soil characteristics by waste disposal, sanitary land fills, mining wastes and human activities, and effects on plants and animals.

Biodiversity and Conservation

Biodiversity concepts and patterns, Microbial diversity, Plant diversity, Agrobiodiversity, Soil biodiversity, Economic value of biodiversity, biodiversity losses. Biodiversity hotspots and their characteristic flora and fauna, threatened plants and animals of India, ecosystem people and traditional conservation mechanisms, Biodiversity Convention and Biodiversity Act, IPRs, national and international programmes for biodiversity conservation. Wildlife values and eco-tourism, wildlife distribution in India, problem in wildlife protection, role of WWF, WCU, CITES, TRAFFIC, Wildlife Protection Act 1972. In-situ conservation: sanctuaries, biospheres reserves, national parks, nature reserves, preservation plots. Ex-situ conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; In-vitro Conservation: germplasm and gene Bank; tissue culture: pollen and spore back, DNA bank.

Forest Ecology

Forest and forest environment: Structure of forest ecosystem, major forest types of the world, forest types and forest cover of India, regeneration ecology of forest trees.

Forest ecosystem function: Primary productivity of forest ecosystems, litter production and decomposition, nutrient cycling and nutrient conservation strategies, plant water relations.

Forest ecosystem management: Forest management systems, joint forest management, forest hydrology, forest fire, application of remote sensing technique in forest ecology, deforestation and sustainable forestry, forest laws, non timber forest products.

Role of Biology in management and habitat management techniques. Wildlife farming: Objectives, management design, wildlife products, disease control, breeding. Behavioral, ecology and evaluation.

Ecosystem Dynamics

The ecosystem concept, abiotic and biotic components. Energy input in ecosystem, standing crop, biomass, primary and secondary production, gross and net production, concept of food chain food web, ten percent law, net community production, methods of measuring productivity, pattern of primary production and biomass in the major ecosystem of the world, Energy flow, Feed back and control. Biogeochemical cycles, gaseous and sedimentary turnover rate and turnover item. Hydrological cycle, carbon cycle, nitrogen cycle, sulphur cycle, phosphorus cycle, nutrient budget, man's impact on nutrient cycles. Population dynamics.

Ecology and Sustainable Development

Ecosystem concept in space and time; Ecosystem level processes and landscape level processes; the concept of sustainable development temporal and spatial dimensions; Currencies for evaluations of sustainable development- Biophysical measurements; Environmental degradations and conservation issues; Global change and sustainability issues: Climate change, biological invasion, bio-diversity concerns; Ecosystem and social processes in: (a) Rehabilitation of degraded rural landscape, (b) Rehabilitation of unbalanced soils, (c) Rehabilitation of specialized habitats, e.g. water bodies, mangroves; (d) Mined area rehabilitation participatory research and education environmental decision making with people initiates.

Bioremediations

Practical aspects of genetic engineering with microorganisms from extreme environment: Use of extremophilic microorganisms in waste treatment and methane production from agro industrial wastes; Production of enzymes like cellulase, proteases, amylases; alcohol and acetic acid production; Biocomposting: Microbial process involvement, vermin composting, biofertilizer, biopesticides production. Biomining: Microbial leaching of low grade mineral ores, molecular probes for organisms in mines and mine tailings, Petroleum pollutant biodegradation. Alternate fuels: Source and mechanism of various biofuel production. Bioremediation: Concept, role of bioremediation in controlling various pollution problems e.g. solid water, sewage water, industrial effluents, heavy metals, radioactive substances, oil spillage. Phytoremediation: Abatement of different types of pollution using plants, types of phytoremediation, mechanism involved with case studies. Waste water treatment strategies: Domestic and Industrial waste-water, application of microbiology waste treatment. Metagenomics: Environmental Genomics, ecogenomics or community genomics, the study of genetic material recovered directly from environmental samples and future applications in bioremediation.

Eco-Toxicology

Principles in toxicology; Definition of Xenobiotics. Animal management in toxicological evaluation; Animal toxicity tests; Statistical concepts of LD50; Dose-effect and dose response relationship; Frequency response and cumulative response; Biological and chemical factors that influence toxicity; Bio-transformation and bio-accumulation. Influence of ecological factors on the effects of toxicity; Concept of green chemistry. Pollution of the ecosphere by industries; Global dispersion of toxic substance; Dispersion and circulating mechanisms of pollutants; degradable and non-degradable toxic substances; food chain. Eco-system influence on the fate and transport of toxicants. Aquatic toxicity tests; Statistical tests; Response of planktons to toxicants; EC49; Photosynthetic bacteria; Bio-absorption of heavy metals. Information management system in eco-toxicology.

Environmental and Occupational Health

Basic principle of environmental health. Physiological responses of man to relevant stresses in the environment. Cases and effects of pollution. Industrial Toxicology: Study of environmental dose effect relationships. Evaluation of toxicity and threshold limits. Principles and methods of occupational health. The relationship of occupation of hygiene and safety and disease. Health maintenance: Survey, analysis and recommendations regarding health and safety problems in the working and living environment. Biostatistics, epidemiology: Application of statistical methods to medical records in the study of health problems of human population in a given environment. Treatment of variation, with demographic, vital statistics and epidemiological data. Hazard evaluation in polluted environment with specific emphasis on radiological health. Industrial hygiene technology-laboratory remains illustrating the principles, methods of recognizing evaluating and controlling environmental hazards like water/air pollution in mining sector etc.

Mining and Environmental Laws

Overview of present environmental problems and efforts to met the challenge; lawmaking and institution building processes; 1972 Stockholm Conference; 1987 Brundtland Commission Report; 1992 UN Conference on Environment and Development; emergence of international environmental law; international environmental institutions including UNEP and other specialized agencies of the UN, conference of parties, secretariats of various multilateral environmental agreements, scientific and technical committees, implementing committees, international funding mechanisms, Commission on Sustainable Development; role of non-state actors; enforcement and dispute settlement mechanism; select multilateral environmental agreements concerning wetlands, endangered species, transboundary air pollution, ozone depletion, Tran boundary movements of hazardous waste, climate change, biodiversity, forests, desertification. Also SAARC regional initiative as well as policy and legislative measures in India for environmental protection.

Sustainable use of resources, natural and man-made, is the desideratum in an environmentally conscious period of human development. Wise use of water, land, forest and other common property resources, such as wet lands, lakes, roads and parks become an important task in this respect.Protection of various energy resources is equally significant element in countering wastage, indiscriminate use and unwise choices.

The Mines and Minerals (Development and Regulation Act, 1957, ('MMDR') and the Mines Act, 1952, together with the rules and regulations framed under them, constitute the basic laws governing the mining sector in India.

The relevant rules in force under the MMDR Act, are the Mineral Concession Rules, 1960, and the Mineral Conservation and Development Rules, 1988. The health and safety of the workers is governed by the Mines Rules, 1955 created under the jurisdiction of the Mines Act, 1952.

The Mineral Concession Rules, 1960 outline the procedures and conditions for obtaining a Prospecting Licence or Mining Lease. The Mineral Conservation and Development Rules, 1988 lays down guidelines for ensuring mining on a scientific basis, while at the same time, conserving the environment. The provisions of Mineral Concession Rules and Mineral Conservation and Development Rules are, however, not applicable to coal, atomic minerals and minor minerals. The minor minerals are separately notified and come under the purview of the State Governments. The State Governments have for this purpose formulated the Minor Mineral Concession Rules.

Mining Acts

MINES AND MINERALS (DEVELOPMENT AND REGULATION) ACT, 1957 CESS & OTHER TAXES ON MINERALS(VALIDATION) ACT, 1992
GOA,DAMAN & DIU MINING CONCESSIONS ACT, 1987

Offshore Areas Mineral (Development and Regulation) Act, 2002

FOREST (CONSERVATION) ACT & RULES,1980

Rules

THE MINERAL CONCESSION RULES, 1960MINERAL CONCESSION RULES AMENDMENT

MINERAL CONSERVATION & DEVELOPMENT RULES, 1988

GRANITE CONSERVATION & DEVELOPMENT RULES, 1999

MINING LEASES (MODIFICATION OF TERMS) RULES, 1956

MINERAL CONSERVATION & DEVELOPMENT RULES(MCDR) FORMS

MINERAL CONCESSION RULES(MCR) FORMS

GRANITE CONSERVATION & DEVELOPMENT RULES(MCR) FORMS

Marble Development and Conservation Rules, 2002

Mineral Concession (Amendment) Rules, 2003 dated 10-04-2003

Mineral Conservation & Development (Amendment) Rules, 2003 dated 10-04-2003

Mineral Conservation & Development (2nd Amendment) Rules, 2003 dated 17-04-2003

Notifications

G.S.R. 49 (E) Mines and Minerals (Development and Regulation) Act, 1957

G.S.R. 153 (E) Mines and Minerals (Development and Regulation) Act, 1957

G.S.R. 280 (E) Mines and Minerals (Development and Regulation) Act, 1957

G.S.R. 833 (E) Mines and Minerals (Development and Regulation) Act, 1957

G.S.R. 963 (E) Mines and Minerals (Development and Regulation) Act, 1957

THE ENVIRONMENTAL IMPACT ASSESSMENT NOTIFICATION, 1994
LABOUR AND SAFETY IN MINES

OVERVIEW OF INDIAN TAX LAWS

Revision Applications & status of other Pending Applications for same area

1. Water

1.1. Salinity

1.2. Bund and spill ways

1.3. Aquaculture and fishing : regulation

1.4. Irrigation

1.5. Ground water management

1.6. Interstate water management and disputes

2. Land

2.1. Controls on land development

2.2. Eco-friendly land planning: conservation, utilisation and conversion.

2.3. Mining and quarrying

3. Concepts of Common Property and State Property

3.1. Forest

3.2. WildlifeLaw 291

3.3. Common facilities and the right to use: roads, parks, pathways, lakes, rivers

3.4. Natural heritage - Tribal habitat

3.5. Historical monuments

3.6. Wet lands: Wise use concept

4. Energy

4.1. Sources

4.2. Energy related environmental problems: tapping, transmission and utilization,

indiscriminate use

4.3. Utilization of conventional energy: hydro-electric, thermal and nuclear

4.4. Non-conventional energy: Solar, wind, tidal and biogas

Select bibliography

Kailash Thakur, Environmental Protection: Law and Policy in India (1997), Deep & Deep publications,New Delhi

WCED, Our Forest, Our Future (1999), Cambridge

Abraham C.M. Environmental Jurisprudence in India (1999), Cluwer.

Diwedi, India's Environmental Policies, Programmes and Stuwardship (1999), Mc.Millan.

Enid M.Barron, et.al. (eds.), Royal Commission on Environmental Pollution, London, U.K.(1998),

Kluwer.David B Wilkins, Animal Welfare in Europe (1997), Kluwer

Mark Austen and Tamara Richards, Basic Legal Documents on International Animal Welfare and Wild Life Conservation (2000), Kluwer.

Jack Grosse, Protection and Management of Our Natural Resources, Wild Life and Habitat (1997),

Oceana.Law 292

Enid.M.Barson and Ilga Nielson (eds.) Agriculture and Sustainable Use in Europe (1998), Kluwer.

Trever Hella Well, Blackston's Guide to Contaminated Land (2000), Blackstone Press.

Leelakrishnan, P et. al. (eds.), Law and Environment (1990)

Leelakrishnan, P, The Environmental Law in India (1999), Butterworths - India

Frodorick R.Anderson, et.al. Environmental Improvement through Economic Incentives (1977)

Indian Journal of Public Administration, Special Number on Environment and Administration, JulySeptember 1988, Vol. XXXV, No.3

David Hughes, Environmental Law, (1999) Butterworths, London

A.R.Bam and P.N.Gantam, Natural Heritage of India (1989), R.K. Publishers, Delhi.

Standing Committee on Environmental Law American Bar Association, Common Boundary/

Common Problems: The Environmental Consequences of Energy Production (1982).

S.K.Jain and A.R.K.Sastry, Threatened Plants of India: A State of the Art Report (1980)

Armin Rozencranz, et.al. (eds.), Environmental Policy and Law in India (1988), Butterworths,

India.

There have been momentous changes in the law of the sea for the last fifty years. An almost settled branch of international law has been reopened in response to the needs of the international community to appropriate limitless resources of the sea for common good. Although the importance of sea as a means of communications has lessened in recent years, new scientific and technological developments have brought to the fore the need of devising an equitable system for the distribution of vast living and non-living resources of the sea. The problems of conservation of vast living and non-living resources are complex. States have been using the sea rather recklessly with the result that there is the danger of pollution and consequent loss of animal life and contamination of the environment. The course on the Law of the sea will, therefore, focus attention on resources of sea as common heritage of mankind. It will necessitate examinations of policy goals of various uses of the sea in the context of dwindling resources on the landmass. It will address itself to problems of conservation, pollution and equitable distribution of resources of the sea-to-sea to nations, large and small, with a seacoast or landlocked. The following syllabus prepared with this perspective will be spread over a period of one semester.

Syllabus

1. Historical introduction to the law of the Sea

2. Changing concepts of Maritime Frontiers

2.1. Rights of states over territorial waters and contiguous zone

2.2. Continental Shelf Law 220

2.3. Exclusive Economic Zone

2.4. Principles for determination of maritime frontiers and Maritime Boundaries under

the customary and conventional law

3. Exploitation of Deep Sea-Bed Resources.

3.1. International Sea Bed Authority, its functions and powers, Decision-making; settlementof disputes, principles governing joint ventures; transfer of data and training of personnel ofthe Authority; Problems and Perspectives.

4. Conservation of Living Resources of the High Sea: Problems of Maritime Pollution.

5. Land-locked States and the Law of the Sea

6. Sea as Common Heritage of Mankind; the Future of the Law of the Sea

7. International Sea Tribunal to Settle Dispute.

Following courses can be zero credit only for remedial purpose

Remedial Mathematics

Functions- polynomial, logarithmic, exponential, absolute value, trigonometric. Limits, Indeterminate forms, Continuity. Derivability. Differentiation of simple mathematical functions- product rule, quotient rule and chain rule. Integration- by parts, substitution and by partial fractions. Linear differential equations and their solution. Introduction to Matrices and Determinants. Introduction to Vectors- addition, subtraction, multiplication of vectors. Equation of Straight Line and Solving Linear System of Equations.

Remedial Biology

History and scope of ecology, Evolution of biosphere, Diversity of life forms. Biological communities, species interaction, Communities properties, succession. Plant diversity and nomenclature with major classes of plants; Phytogeographical regions; Rare and threatened plants and exploration of plant wealth. Animal diversity and categories of animals; Rare and threatened species of mammals, aves, reptiles, pisces etc.; Exploration and conservation of faunal wealth. Microbial diversity, bacteria, fungi, actinomycetes; Microbial diversity in man-made ecosystems and natural ecosystems. Importance of flora and fauna in nutrient cycling, its effect, degradation and metabolism.

Environmental chemistry

Fundamental Chemistry: Elements, Chemical bonding, chemical reactions and equations, Organic functional groups, classes of organic compounds. Free radical reactions, catalytic processes. Elemental cycles (C, N, S, O) and their environmental significance. Fossil fuels: their types, properties, combustion and environmental implications.Atmospheric constituents, Green house gases and climatic changes. Chlorofluorocarbons and their substitutes. Photochemical smog. Water quality and wastewater treatment. Role of soaps, detergents and phosphorus fertilizers in eutrophication. Persistent organic pollutants: pesticides usage, toxicity and their environmental degradation. Earth crust and weathering mechanism; Soil formation and chemical characteristics. Chemical classes of Hazardous waste, their effects on the environment. Chemical treatment of hazardous wastes.

Statistics

Measures of central tendency. Measures of dispersion. Measures of skewness and kurtosis. Probability- definition, addition and multiplication laws,concept of random variable. Probability distributions- binomial, poisson and normal. Sampling theory- hypothesis testing and interval estimation for large samples. Chi-square test, t-test and F-test of significance. Correlation and regression. analysis. One way analysis of variance.